DOCUMENT RESUME

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TITLE	Introduction to Metal Bonded Repair, 13-4. Military Curriculum Materials for Vocational and Technical Education.
INSTITUTION	Air Training Command, Randolph AFB, Tex.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
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NOTE	83p.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Air Transportation; Behavioral Objectives; Course Descriptions; Inspection; Learning Activities; Lesson Plans; Maintenance; *Metals; *Metal Working; Postsecondary Education; *Repair; Safety; Secondary Education; *Trade and Industrial Education
IDENTIFIERS	*Adhesion Bonding; *Metal Bonded Repair; Military Curriculum Project

ABSTRACT

These instructor materials and student study guide for a secondary/postsecondary level course in metal-bonded repair comprise one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. The purpose stated for the course is to train students in the knowledge and skills necessary to perform as managers and repair technicians in adhesive bonding shops. Designed as an additional specialty for students with experience in metals processing, the course can be used as a sub-unit or for advanced study in a metals processing course. The course consists of one block covering 26 hours of instruction. Four lessons cover these topics: course orientation and safety, introduction to metal bonded structures, principles of repair processes, and inspection and evaluation. Instructor materials include a course chart; a plan of instruction detailing units of instruction, criterion objectives, lesson duration, and support materials needed; and lesson plans. The study guide contains objectives, text material, references, and review exercises. Audiovisuals are suggested for use but are not provided. (YLB)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL

Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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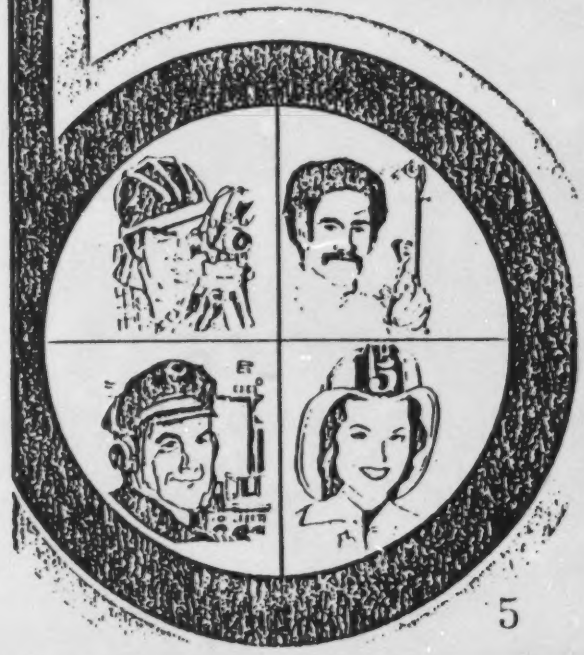
Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education



Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

INTRODUCTION TO METAL BONDED REPAIR

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Inspection And Evaluation	Page 70

Developed by:

United States Air Force

Development and Review Dates

July 2, 1975

D.O.T. No.:
812.884
Occupational Area:
Machine Shop
Target Audiences:
Grades 11-adult

Print Pages:
68
Cost:

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:							Instructional Design:				Type of Instruction:		
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:	
Block I — *Introduction to Metal Bonded Repair*								★					
Course Orientation and Safety	•				•	★	•		•		•		
Introduction to Metal Bonded Structures	•				•	★	•		•		•		
Principles of Repair Processes	•				•	★	•		•		•		
Inspection and Evaluation	•				•	★	•		•		•		

★ Materials are recommended but not provided.

2.

Course Description:

This course trains students in the knowledge and skills necessary to perform as managers and repair technicians in adhesive bonding shops. The scope of training includes an introduction to metal bonded structures, principles of repair processes, and inspection and evaluation. Safety is emphasized throughout the course. This course was designed as an additional specialty for students with experience in metals processing.

The course consists of one block covering 26 hours of instruction. The block contains four lessons. One lesson discussing military documents and publications has been deleted. The remaining lesson topics and hours follow:

Course Orientation and Safety (2 hours)
Introduction to Metal Bonded Structures (8 hours)
Principles of Repair Processes (15 hours)
Inspection and Evaluation (1 hour)

This course contains both teacher and student materials. Printed instructor materials include a course chart; a plan of instruction detailing units of instruction, criterion objectives, the duration of the lessons, and support materials needed; and lesson plans for each lesson. Student materials consist of a study guide containing objectives, text material, references, and review exercises. This course can be used as a sub-unit or advance study in a metals processing course.

Audiovisuals suggested for use with the course, but not provided include 168 transparencies and 224 commercially produced slides.

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COURSE CHART

13-4

NUMBER	PDS CODE	DATE
3AZR53153-3	S4D	15 April 1975

COURSE TITLE: Introduction to Metal Bonded Repair

ATC OPR AND APPROVAL DATE	CENTER OPR	SUPERSEDES COURSE CHART
TTMS, 21 Oct 74	Chanute/TTOXW	3AZR53450-6, 3 September 1974

DEPARTMENT OPR	APPLICABLE TRAINING STANDARD CTS
Department of Weapon Systems Support Training	CH52-3AZR53153-3, 14 Apr 75
LOCATION OF TRAINING	COURSE SECURITY CLASSIFICATION
Chanute AFB, Illinois 61868	UNCLASSIFIED
INSTRUCTIONAL DESIGN	TARGET READING GRADE LEVEL FOR PREPARATION OF TRAINING LITERATURE
Group/Lock Step	8

LENGTH OF TRAINING (1 Weeks, 0 Days)

	Hours	
Technical Training (TT)		
Classroom/Laboratory (C/L)	30	38
Complementary Technical Training (CTT) (assigned study)	8	
Related Training (RT)		2
Appointments, Traffic Safety Predeparture Briefing, End of Course	2	
TOTAL		40

REMARKS

Effective Date: 1 July 1975 with class 750702

TABLE I - MAJOR ITEMS OF EQUIPMENT

COURSE CHART – TABLE II – TRAINING CONTENT 3AZR53153-3

NOTE: Include time spent on technical training (TT) (classroom/laboratory (C/L) and complementary technical training (CTT)) and related training (RT). Exclude time spent on individual assistance (remedial instruction). A single entry of time shown for a unit is C/L time. When a double entry is shown, the second entry is CTT time.

WK OF TNG \ HRS PER DAY	1	2	3	4	5	6	7	8
1	Course Material - UNCLASSIFIED BLOCK I - 38 Hours TT Course Orientation and Safety (2 hrs) Technical Documents and Publications (2 hrs) Introduction to Metal Bonded Structures (8 hrs) Principles of Repair Processes (15 hrs) Inspection and Evaluation (1 hr) Measurement Test and Test Critique (1 hr) Course Critique and Graduation (1 hr) (Equipment hazards and personnel safety integrated with above subjects) 30 Hours C/L						8 Hours CTT	2 Hours RT

DEPARTMENT OF THE AIR FORCE
Headquarters, Air Training Command
Randolph Air Force Base, Texas

CTS CH52-3AZR53153-3
(PDS Code S4D)
14 April 1975

3

INTRODUCTION TO METAL BONDED REPAIR

1. Purpose. This course training standard as prescribed in ATCR 52-17:

a. Establishes the tasks, knowledges and proficiency level of training to be provided by Course 3AZR53153-3, Introduction to Metal Bonded Repair.

b. Provides the basis for the development of more detailed training materials and objectives and training evaluation instruments for the course.

2. Course Description. The course covered by this standard is designed to train selected Air Force personnel who possess AFSC 53153/73 or equivalent civilian experience (as well as management and quality assurance personnel) in the knowledges necessary to perform as managers and repairmen in depot level adhesive bonding shops. Scope of training includes technical documents and publications, introduction to metal bonded structures, principles of repair processes, and inspection and evaluation. Safety will be emphasized in all applicable subject areas.

3. Qualitative Requirements. Attachment 1 contains the list of tasks, knowledges, and proficiency levels referenced in paragraph 1.

4. Recommendations. Comments and recommendations are invited concerning quality of ATC training and graduates. Use this CTS as a reference and address correspondence to ATC/TT, Randolph AFB, Texas 78148.

OFFICIAL

GEORGE H. McKEE, Lt Gen, USAF
Commander

DAVID H. BUSS, Colonel, USAF
Director of Administration

1 Attachment
Qualitative Requirements

This supersedes CTS CH52-3AZR53450-6, 3 September 1974.
ATC OPR & Approval Date: TTMS, 21 Oct 74
DISTRIBUTION: X (Continued on Page 2)

QUALITATIVE REQUIREMENTS

CTS CH52- 3A2R53153 -3

PROFICIENCY CODE KEY		
	SCALE VALUE	DEFINITION: The Individual
TASK PERFORMANCE LEVELS	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task. (HIGHLY PROFICIENT)
*TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can determine step by step procedures for doing the task. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (COMPLETE THEORY)
**SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject. (PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

– EXPLANATIONS –

* A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. (Examples: b and 1b)

** A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

– This mark is used alone instead of a scale value to show that no proficiency training is provided in the course, or that no proficiency is required at this skill level.

X This mark is used alone in course columns to show that training is not given due to limitations in resources.

DISTRIBUTION: (Continued from Page 1) AFLC/DPMTT - 2; ATC/DPATJ - 1; AFLC/MAUT - 2; ATC/TTMS - 1; Chanute: XRP - 1; TTE - 1; TTOC - 1; TTOXW - 1; TWS - 25.

Task, Knowledge and Proficiency Level

1. SAFETY IN WORK AREA	
a. Safety precautions during job performance	C
b. Safety precautions while handling repair materials	C
2. TECHNICAL DOCUMENTS AND PUBLICATIONS	B
3. METAL BONDED SANDWICH CONSTRUCTION	
a. Adhesive joints	B
b. Bonded sandwich construction	B
c. Chemistry of adhesion and polymerization	A
d. Repair Materials	C
4. REPAIR PROCESSES	
a. Assessment of damage	B
b. Preparation for repair	C
c. Fabrication and prefit	C
d. Cleaning	C
e. Lay-up and assembly	C
f. Curing	C
g. Inspection	B
h. Trimming and final finish	C
5. USAF GRADUATE EVALUATION PROGRAM	C

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POI 3AZR53450-6
(PDS Code 54D)

PLAN OF INSTRUCTION

(Technical Training)

INTRODUCTION TO METAL BONDED REPAIR

CHANUTE TECHNICAL TRAINING CENTER

2 July 1975 - Effective 2 July 1975 with Class 750702

9.

POI 3AZR53450-6

LIST OF CURRENT PAGES

This POI consists of 9 current pages issued as follows:

Page No.	Issue
Title	Original
A	Original
i	Original
1 thru 5	Original
A1-1	Original

DISTRIBUTION: ATC/TTMS-1, AULD-1, TWS-30, TTOC-3, TTOT-1, TTOXW-1, TTOR-1, TTE-1, CCAF/AY-2

DEPARTMENT OF THE AIR FORCE
USAF School of Applied Aerospace Sciences (ATC)
Chanute Air Force Base, Illinois 61868

PLAN OF INSTRUCTION 3AZR53450-6
(PDS Code 54D)
2 July 1975

FOREWORD

1. PURPOSE. This plan of instruction prescribes the qualitative requirements for Course Number 3AZR53450-6, Introduction to Metal Bonded Repair, in terms of criterion objectives presented by units/modules of instruction, and shows duration, correlation with the training standard, support materials, and instructional guidance. It was developed under the provisions of ATCR 52-33, Instructional System Development and ATCR 52-7, Plans of Instruction.

2. COURSE DESCRIPTION. Training consists of technical training and related training. In technical training, the course trains selected Air Force personnel who possess AFSC 53450/70 or equivalent civilian experience (as well as management and quality assurance personnel) in the knowledges necessary to perform as managers and repairmen in depot level adhesive bonding shops. Training includes safety precautions, technical documents and publications, introduction to metal bonded structures, principles of repair processes, and inspection and evaluation. Related training covers commander's calls/briefings, etc.

3. EQUIPMENT ALLOWANCE AND AUTHORIZATION. None.

4. MULTIPLE INSTRUCTOR REQUIREMENTS. Not applicable to this POI.

5. REFERENCES. This plan of instruction is based on COURSE TRAINING STANDARD CH52-3AZR53450-6, 3 September 1974, and Course Chart 3AZR53450-6, 3 September 1974.

FOR THE COMMANDER

WILLIAM R. MITCHELL, Colonel, USAF
Chief, Operations Division

OPR: Department Weapons Systems Support Training
DISTRIBUTION: Listed on page A

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
2. Technical Documents and Publications a. Without reference, identify the basic facts and principles concerning technical documents and publications pertaining to the metal bonding process without error.	2.5 (2/.5)	Column 1 Reference: 2a — CTS Reference: 2 Instructional Materials 3AZR53450-6-SG-102, Technical Documents and Publications MIL-HDBK-23A MIL-A-83376 MIL-A-83377 Training Methods Discussion (2 hrs) Outside Assignments (.5 hr) Instructional Environment/Design Classroom (2 hrs) Instructional Guidance Give each student copies of required military handbooks, explain the MIL-HDBK arrangement and how to find information in the HDBK. Discuss procedures used in determining which facts and principles will be of use to student in these publications. Outside assignment: accomplish the study assignment in 3AZR53450-6-SG-102. Answer all questions at the end of the study guide.
3. Introduction to Metal Bonded Structures a. Without reference, identify the principles involved in bonding adhesive joints without error. b. Without reference, identify basic facts and general principles as to how a bonded sandwich assembly is constructed and what materials are used in the construction of bonded sandwich assemblies without error.	11 (8/3) (1) (3)	Column 1 Reference — CTS Reference 3a — 3a 3b — 3b 3c — 3d 3d — 3c Instructional Materials 3AZR53450-6-SG-103, Introduction to Metal Bonded Structures 3AZR53450-6-HO-103, Glossary of Terms MIL-HDBK-23A MIL-A-83376 MIL-A-83377

PLAN OF INSTRUCTION NO. 3AZR53450-6	DATE 2 July 1975	BLOCK NO. I	PAGE NO. 2

ATC FORM MAR 73 337A — PREVIOUS EDITIONS OBSOLETE. — (Final Copy – 84% – 8 X 10½) — (Final reduction to exclude area above this line)

PLAN OF INSTRUCTION	COURSE TITLE Introduction to Metal Bonded Repair

BLOCK TITLE

Introduction to Metal Bonded Repair

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
1. Course Orientation and Safety a. Orientation will be conducted IAW school regulation 50-18, attachment 3 outline. b. Given job performance situations, analyze the situations and identify safety precautions to be observed during job performance without error. c. Given repair material handling situations, analyze the situations and identify the safety precautions to be observed without error.	2.5 (2/.5)	Column 1 Reference / CTS Reference 1a / None 1b / 1a 1c / 1b Instructional Materials 3AZR53450-6-SG-101, Course Orientation and Safety AFM 127-101, Industrial Safety Accident Prevention Handbook MIL-HDBK-23A, Structural Sandwich Composites MIL-A-83376, Adhesive Bonded Aluminum Honeycomb Sandwich Structures MIL-A-83377, Guidelines for Adhesive Bonding for Aerospace Systems Training Methods Discussion (2 hrs) Outside Assignments (.5 hr) Instructional Environment/Design Classroom (2 hrs) Group/Lock Step (NOTE: Group/Lock Step is applicable to entire course.) Instructional Guidance Complete locator cards, tour school facilities. Discuss safety precautions pertaining to hand and power tools used in metal bonded repair. Discuss storing and handling of chemicals and adhesives. Discuss importance of dust free environment in controlled areas. Conservation of resources and materials: caution students not to mark, mutilate, or write on any training literature; it is to be reused by subsequent classes. Outside assignment: read and study 3AZR53450-6-SG-101. Answer all questions at the end of study guide.

PLAN OF INSTRUCTION NO. 3AZR53450-6	DATE 2 July 1975	BLOCK NO. I	PAGE NO. 1

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
d. Given a bonded repair situation, analyze the situation and identify the types and methods of cleaning metal bonded structures IAW technical data. e. Given a bonded repair situation, analyze the situation and identify facts and principles related to the lay-up and assembly of the repair materials IAW technical data. f. Given a bonded repair situation, analyze the situation and identify facts and principles pertaining to the curing process IAW technical data. g. Given a metal bonded repair situation, analyze the situation and identify the facts and principles concerning trimming and final finish IAW technical data.	(3) (2) (3) (1)	Training Methods Discussion (15 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (15 hrs) Instructional Guidance Given MIL-HDBK-23A, study guide 3AZR53450-6-SG-104, and handout 3AZR53450-6-HO-103, Glossary of Terms, read and discuss repair processes. Discuss types of inspections and steps in assessment of damage to metal bonded structures. Discuss the steps and methods involved in the preparation of metal bonded structures for repair. Read and discuss the steps associated with fabrication and prefit. Identify types and methods used in cleaning metal bonded structures. Student will watch film on F-15 and then discuss principles related to lay-up and assembly of metal bonded structures. Read and discuss facts pertaining to the curing process of metal bonded structures. Discuss facts involved in the trimming and final finishing stages of metal bonded structures. Discuss the various tools and equipment used in fabricating and bonding panels. Day 3 outside assignment: read study guide 3AZR53450-6-SG-104 and accomplish assignment number 1. Day 4 outside assignment: read study guide 3AZR53450-6-SG-104 and accomplish assignment number 2.
5. Inspection and Evaluation a. Without reference, identify the general principles and basic facts concerning inspection of metal bonded structural repairs IAW technical data.	1	Column 1 Reference: 5a — CTS Reference: 4g Instructional Materials 3AZR53450-6-SG-105, Inspection and Evaluation MIL-HDBK-23A MIL-A-83376 MIL-A-83377 Training Methods Discussion (1 hr)

PLAN OF INSTRUCTION NO. 3AZR53450-6	DATE 2 July 1975	BLOCK NO. I	PAGE NO. 4

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
c. Given various adhesives, analyze and identify characteristics of the repair materials used in the repair of metal bonded structures without error.	(3.5)	Training Methods Discussion (3 hrs) Outside Assignments (3 hrs) Instructional Environment/Design Classroom (3 hrs)
d. Without reference, identify the basic facts and terms regarding adhesion and polymerization of adhesives without error.	(.5)	Instructional Guidance Given military handbooks (MIL-HDBK-23A, MIL-A-83376, MIL-A-83377), study guide 3AZR53450-6-SG-103, and handout 3AZR53450-6-HO-103, Glossary of Terms, read and discuss principles of adhesive joints. Discuss construction and materials that are associated with depot level bonding procedures. Have students identify materials used in metal bonding. Give students introduction to adhesion and polymerization. Go over Glossary of Terms. Outside assignment: accomplish the study assignment in 3AZR53450-6-SG-103. Answer all questions at end of study guide.
4. Principles of Repair Processes	19 (15/4)	Column 1 Reference / CTS Reference 4a / 4a 4b / 4b 4c / 4c 4d / 4d 4e / 4e 4f / 4f 4g / 4h
a. Without reference, identify basic facts and principles concerning the assessment of damage to metal bonded structures IAW technical data.	(1)	
b. Given a bonded rupair situation, analyze the situation and identify the steps and procedures in the preparation for repair of a bonded panel IAW technical data.	(3)	Instructional Materials 3AZR53450-6-SG-104, Principles of Repair Processes MIL-HDBK-23A MIL-A-83376 MIL-A-83377
c. Given a bonded repair situation, analyze the situation and identify the steps and procedures associated with the fabrication and prefit of repair parts IAW technical data.	(2)	Audio Visual Aids Film CF72-1161, F-15 Composite Wing Development

4 PLAN OF INSTRUCTION NO. 3AZR53450-6	DATE 2 July 1973	BLOCK NO. I	PAGE NO. 3

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION HOURS	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (1 hr) Instructional Guidance Given MIL books (MIL-HDBK-23A, MIL-A-83376, MIL-A-83377) and study guide 3AZR53450-6-SG-105, read and discuss material as it pertains to the inspection and evaluation of metal bonded assemblies. Then have students inspect and evaluate their panels.
6. Related Training (identified in course chart)	2	
7. Measurement Test and Test Critique	1	
8. Course Critique and Graduation	1	

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE	INSTRUCTOR
TWSTI 19 Nov 75 Exam	
COURSE NUMBER: 3AZR53153-3	COURSE TITLE: Introduction to Metal Bonded Repair
BLOCK NUMBER: 1	BLOCK TITLE: Introduction to Metal Bonded Repair

LESSON TITLE: Course Orientation and Safety

LESSON DURATION		
CLASSROOM /Laboratory	Complementary	TOTAL
D&D 2 hrs/Per. None	.5 hrs	2.5 hrs

POI REFERENCE		
PAGE NUMBER	PAGE DATE	PARAGRAPH
1	2 Jul 1975	1a,1b,1c, /d

STS/CTS REFERENCE	
NUMBER	DATE
CH52-3AZR53153-3	14 April 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	3AZR53153-3-SG-101 AFR 127-101 MIL-HDBK-23A MIL-A-83376 MIL-A-83377 4 OTT G-54-75-1

CRITERION OBJECTIVES AND TEACHING STEPS

1. Course Orientation and Safety

a. Orientation will be conducted IAW school regulation 50-18, attachment 3 outline.

b. Given job performance situations, analyze the situations and identify safety precautions to be observed during job performance without error.

c. Given repair material handling situations, analyze the situations and identify the safety precautions to be observed without error.

d. To prepare the advanced course students with knowledges of the purpose and operation of the Graduate Evaluation Program so that they may effectively use the system.

Teaching steps are listed in Part II

ATC FORM AUG 72 770

☆ GPO: 1973 778-388/23

INTRODUCTION TIME: 5 Min

ATTENTION: Hey man! Aircraft so large you can play a game of football in the cargo bays, acres of honeycomb construction, as a real tin benders night mare, no not really. The real secret to todays modern aircraft maintenance is not to be humbled by these size, be familiar with the new modern repair concepts. In essence, the days of chewing gum and bailing wire are gone.

REVIEW: I'm sure you have all attended a course of some type since you have been in the service. The knowledge we hope to give you here will be an extension of the skill and the knowledge you should already have.

OVERVIEW: This will be a two hour lesson that will ocver orientation and safety. As you have found out I'm sure, all courses in ATC have some ground safety.

MOTIVATION: The information found in this lesson will familiarize you with some of the new or for some of you not so new concepts of safety as applied in the bonded Honeycomb areas. There are some new ideas which apply to your area now and we will try to cover as many as possible.

BODY TIME: 1 Hr 50 Min.

Presentation	Presentation
1. Orientation a. Course orientation will be conducted IAW SR 50-18, attachment 3 outline. (1) Course policies a. Duty hours b. Uniform c. Parking d. Appearance e. Locator cards	Discussion Conservation of resources and materials, caution students not to mark, mutilate, or write on any training literature. It is to be reused by subsequent classes. Ref. AFR 127-101 MIL-HDBK -23A MIL-A-83376 MIL-A-83377

1

BODY (cont)

(2) Classroom responsibilities

a. class leader

b. clean up

(3) Organizational structure

a. department

b. branch

c. course supervisor

d. instructor or supervisor

e. instructor

(4) Course content

a. block of instructions

b. units of instructions

c. course critique

(5) Community College of the Air Force

(6) Location of tools and equipment

(7) Tour of School Facilities

2. To prepare the advanced course student with knowledge of the purpose and operation of the Graduate Evaluation Program so that they may effectively use the system.

a. Purpose

b. Responsibilities of supervisor

(1) Furnish information

Interim summary

USO 4077 G-SC-75-1

BODY (cont)	
(2) Establish procedures	
(3) Recommend Changes	
(4) Inform higher headquarters of dificiencies	
c. Evaluation of graduates	
(1) Field Evaluation Visits	
(2) Direct correspondence questionnaires	
(3) Job Performance Valuation	
(4) AF Form 1284	
3. Given job performance situations, analyze the situations and identify safety precautions to be observed during job performance without error.	
a. Identify safety hazards in handling hand and power tools in the bonding.	
(1) Hand tools	
a. knives	
b. scissors	
b. Identify personnel safety equipment	
(1) goggles	
(2) gloves	
(3) respirators	Interim summary
4. Given repair material handling situations, analyze the situation- and identify the safety precautions to be observed without error.	

BODY (cont)

a. Handling adhesives

b. Handling cleaners

c. Handling fiberglass cloth and films

(1) Breathing

(2) Sanding

(3) Cutting

d. Identify storage areas

(1) Quantities on hand

(2) Location of cabinets

(3) Ventilation

e. Identify hazards of chemicals

(1) Explosive and toxic fumes

(2) Bodily harm or effects of toxic fumes and vapors

BODY (cont)

Application	Performance
None	None
Evaluation: Evaluation is interspersed throughout the lesson.	

CONCLUSION TIME: 5 Min

Summary and Remotivation: In this lesson we discussed course policies, course content and ground safety. We discussed safety precautions to be observed while you are in this school. The hazards in handling hand and power tools, personnel safety equipment, routing operations, storage areas, protective clothing. I also demonstrated the explosimeter. This is information you need to know to be able to understand what you will be doing while you are here and the safety precautions to be observed.

Assignment and Closure: The next lesson will be on technical documents and publications that pertain to metal bonding areas. CTT Assignment (objective 1a, 1b, 1c) using 3AZR53153-3-SG-101, read and answer questions in the study guide. This is a .5 hour outside assignment.

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APPROVAL OFFICE AND DATE	INSTRUCTOR
TWSTI	
COURSE NUMBER	COURSE TITLE
3AZR53153-3	Introduction to Metal Bonded Repair
BLOCK NUMBER	BLOCK TITLE
1	Introduction to Metal Bonded Repair

22

LESSON TITLE
Introduction to Metal Bonded Structures

LESSON DURATION		
CLASSROOM /Laboratory	Complementary	TOTAL
D&D 8 hrs/ Perf. None	3 hrs	11 hrs

POI REFERENCE		
PAGE NUMBER	PAGE DATE	PARAGRAPH
2	2 July 1975	3a,3b,3c,3d

STS/CTS REFERENCE	
NUMBER	DATE
CH52-3AZR53153-3	14 April 1975

SUPERVISOR APPROVAL			
SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION			
EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	3AZR53153-3-SG-103 ~~3AZR53153-3-HO-103~~, MIL-HDBK-23A MIL-A-83376 MIL-A-83377 Transparencies: Model Bonded Repair Procedures

CRITERION OBJECTIVES AND TEACHING STEPS

3. Introduction to Metal Bonded Structures

a. Without reference, identify the principles involved in bonding adhesive joints without error.

b. Without reference, identify basic facts and general principles as to how a bonded sandwich assembly is constructed and what materials are used in the construction of bonded snadwich assemblies without error.

c. Given various adhesives, analyze and identify characteristics of the repair materials used in the repair of metal bonded structures without error.

d. Without reference, identify the basic facts and terms regarding adhesion and polymerization of adhesives without error.

Teaching steps are listed in Part II.

ATC FORM AUG 72 770

INTRODUCTION TIME: 5 Min

Attention: In bonding the proper selection of an adhesive must be made to be compatible with the substrate being joined modern day technology. No this is from the Bible. Problems in bonding have been around since the beginning of Time.

Review: With two lessons under our belt let's get into the meat of the problem.

Overview: This is an 8 hour discussion on Metal Bonded Structures.

Motivation: How you do your job is important in that a proper repair or rebuilding not only means aircraft safety but job repeats.

BODY TIME: 7 hrs 50 Min.

Presentation	Presentation
1. Without reference, identify the principles involved in bonding adhesive joints without error. a. History of adhesives 1. earliest adhesives 2. twentieth century adhesives 3. present day adhesives b. Design considerations, chapter 2 1. surface conditions of the adherend.	Discussion Reference: Adhesives in Modern Manufacture MIL-HDBK-23A MIL-A-83376 MIL-A-83377 Uw Trans CT 75·C163

2. Surface tension of adhesive

3. Physical properties of the adherends and the cured adhesive

a. tensile strength

b. shear strength

c. compressive strength

4. Physical characteristic of the adhesive

a. viscosity

b. homogeneity

c. film thickness

5. Chemical compatiblity of the adhesive and the adherend

6. Application and curing the adhesive

7. Formation and removal of volatile by products during cure.

2. Without reference, identify basic facts and general principles as to how to a bonded sandwich assembly is constructed and what materials are used in the construction of bonded sandwich assemblies without error.

a. Primary reason of sandwich construction over convention A/C construction.

Use Trans CT 75-C165 thru CT 75-C163

Use Trans CT 75-C143 thru CT 75-C147

Interim Summary

1. High strength - to-weight ratio
2. Fatigue resistance
3. High rigidity per unit weight
4. Surface smoothness
5. Insulation

b. Sandwich construction features

1. Facings

Use trans CT75-C15a thru CT75-C16

a. purpose

b. materials

2. Core

a. purpose

b. materials

3. Edge treatments (close outs)

a. purpose

b. types

c. construction features

Demonstration — None

Application — None

Evaluation

1. Evaluation will be interspersed throughout the lesson.

End of Day Summary

Summary: We have had a short discussion the introduction to metal bonded repair. We have also become acquainted with the materials you will use in the field.

Restate the objectives of the lesson:

Ask Oral Questions to Determine Areas to be Retaught:

Assignment: CTT Assignment (objectives 3c, -3d). Read 3AZR53153-3-SG-103, ~~3AZR53153-3-HO-103~~. Be prepared to answer questions about adhesion, polymerization. This is a 1½ hr outside assignment.

3

Introduction to New Days Work

Motivation: Arouse student interest:

Review: Review CTT assignment

Review items of major importance.
Review objectives of previous day.
State objectives to be covered in this particular lesson.

Body (cont)	2nd Day
Presentation #2	Presentation
1. Given various adhesives, analyze and identify characteristics of the repair materials used in the repair of metal bonded structures without error.	Discussion
a. Selection of adhesives	Use Trans CT 75-C 146 Ref. CT 75-C 153
1. materials involved	
2. application	
3. environmental exposures	
4. service life	
5. weight considerations	
b. Edge treatments	Use Trans CT 75 C 154 Ref. CT 75-C 153
1. purpose	
2. types	
3. materials used	Interim summary
2. Without reference, identify the basic facts and terms regarding adhesion and polymerization of adhesives without error.	

1.

a. Adhesion 1. definition 2. theory b. Polymerization 1. definition 2. theory	Interim Summary

CONCLUSION TIME: 5 Min

Summary and Remotivation: In this lesson we discussed ideas and information pertaining to your introduction to metal bonded structures. Realistically speaking we have just scratched the surface. I would imagine that even while we were discussing this material something new has come about in this ever changing field of structural repair.

Assignment and Closure: The next less will be on Principles of Repair Processes, this will expose you to the how and whys of Repair of Metal Bonded Structures. Assignment - Review 3AZR53153-3-SG-103. Answer all questions at the end of study guide. This is a 1½ hr outside assignment.

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APPROVAL OFFICE AND DATE	INSTRUCTOR
TWSTI [illegible]	
COURSE NUMBER: 3AZR53153-3	COURSE TITLE: Introduction to Metal Bonded Repair
BLOCK NUMBER: 1	BLOCK TITLE: Introduction to Metal Bonded Repair

LESSON TITLE: Principles of Repair Processes

LESSON DURATION		
CLASSROOM/Laboratory	~~LABORATORY~~ Complementary	TOTAL
D&D 15 hrs/Perf. None	4 hours	19 hours

POI REFERENCE		
PAGE NUMBER	PAGE DATE	PARAGRAPH
3	2 July 1975	4a,4b,4c,4d,4e,4f,4g

STS/CTS REFERENCE	
NUMBER	DATE
CH52-3AZR53153-3	14 April 1975

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	3AZR53153-I-SG-104 MIL-HDBK-23A MIL-A-83376 MIL-A-83377 Adhesives in Modern Manufacturing, Chap 4, Chap 5 (cont on back)

CRITERION OBJECTIVES AND TEACHING STEPS

4. Principles of Repair Process

a. Without reference, identify basic facts and principles concerning the assessment of damage to metal bonded structures IAW technical data.

b. Given a bonded repair situation, analyze the situation and identify the steps and procedures in the preparation for repair of a bonded panel IAW technical data.

c. Given a bonded repair situation, analyze the situation and identify the steps and procedures associated with the fabrication and prefit of repair parts IAW technical data.

d. Given a bonded repair situation, analyze the situation and identify the types and methods of cleaning metal bonded structures IAW technical data.

e. Given a bonded repair situation, analyze the situation and identify facts

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SAFB IL 21-2500

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Graphic Aids and Unclassified Materials (cont.)
Transparencies. Metal Bonded Repair Procedures
Film [illegible] F-15 Composite [illegible], Development

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and principles related to the lay-up and assembly of the repair materials IAW technical data.

f. Given a bonded repair situation, analyze the situation and identify facts and principles pertaining to the curing process IAW technical data.

g. Given a metal bonded repair situation, analyze the situation and identify the facts and principles concerning trimming and final finish IAW technical data.

Teaching steps are listed in Part II

INTRODUCTION	5 Min

Attention: When we get an aircraft part in the shop we must be able to recognize what damages and what repairs need to be made. Along with this goes the knowledge and principles of what make a good repair.

Review: This lesson will prepare you for our next lesson.
Review CTT assignment

Overview: This is a 15 hour lesson.

Motivation: How you accomplish your repair, and doing the proper repair will be most helpful to you and the Air Force.

BODY	TIME: 14 Hrs 50 Min.
Presentation	Presentation
1. Without reference, identify basic facts and priciples concerning the assessment of damage to metal bonded structures IAW Tech Data.	Discussion Reference: MIL-HDBK-23A MIL-A-83376 MIL-A-83377 Adhesives in Modern Manufacture Slide presentation CS75-C74 thru CS75-C153 interspersed throughout lesson use trans CT75-C174 thru CT75-C178
a. Damage Classification of Metal Bonded Structures	
1. Class 1 Repairs	
a. Dents	a. Not to exceed ¼ inch in all dimensions.
b. Scars	
c. Fractures	
2. Class II Repairs	
a. Punctures	b. One facing and partial core damage.
b. Fractures	

2. Given a bonded repair situation, analyze the situation and identify the steps and procedures in the preparation for repair of a bonded panel IAW Tech Data.

a. Routers and Routing

b. Deburring Holes

c. Clean up of the cavity

End of Day Summary

Summary:

Restate the objectives of the lesson:

Ask Oral Questions to Determine Areas to be Retaught:

Assignment: CTT Assignment (Objective 4a and 4b)

Read and answer question in 3AZR53153-3-SG-104, Principles of Repair Processes. This is a 2 hr CTT assignment

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Introduction to New Days Work

Motivation:

Arouse student interest.

Review: Review CTT assignment

Review items of major importance.

Review objectives of previous day

State objectives to be covered in this particular lesson.

Body (cont) 2nd Day

Presentation #2

1. Given a bonded repair situation, analyze the situation and identify the steps and

procedures associated with the fabrication and prefit of repair parts IAW Technical Data.

a. Replacement Core
   1. replacement material
   2. ribbon direction
   3. density

b. Core Fill Materials
   1. types
   2. use
   3. fabrication procedures

c. Facing Patches
   1. types
   2. materials
   3. fabrication procedures

d. Prefit and Fabrication Tools
   1. core cutters
   2. arbor saws
   3. core slicers

End of Day Summary

Summary:

Restate the objectives of the lesson:

Ask Oral Questions to Determine Areas to be Retaught:

Assignment: CTT assignment (Objective 4c)

Read Adhesives in Modern Manufacturing Chap 4, Chap 5. This is a 2 hr. CTT assignment

Introduction to New Days Work

Motivation:

Arouse student's interest:

Review: Review CTT assignment

Review items of major importance.

Review objectives of previous day.

State objectives to be covered in this particular lesson.

Body (cont) 3rd Day

Presentation #3

1. Given a bonded repair situation, analyze the situation and identify the types and methods of cleaning metal bonded structures IAW Technical Data.

a. Surface Preparation for Metals

1. chemical

2. mechanical

b. Surface Preparation for Nonmetallic Materials

1. Abrasive cleaning

c. Chemical Preparation for Adherends

1. Degreasing

2. Alkaline cleaning

3 Etching

Use trans CT75-C179 thru CT75-C182

d. Surface preparation for aluminum

e. Surface preparation for stainless steel

f. Miscellaneous cleaning methods

1. Soaps and detergents

2. Hand tools

3. Pneumatic tools

2. Given a bonded repair situation, analyze the situation and identify facts and principles related to the lay-up and assembly of the repair materials IAW Technical Data.

a. Manual Adhesive Application Methods

1. Brushes

2. Spatula

3. Rollers

b. Machine Application Methods

1. Mechanical Rollers

2. Spray Applicators

c. Cold Setting and Hot Setting Adhesives

1. Cold-Setting Adhesives

2. Hot Setting Adhesives

d. Classifying Adhesives by Initial Bond

1. Pressure-sensitive

2. Contact

3. Chemical Setting

4. Heat-setting

5. Liquid - release

e. Drying Process

BODY (cont.)

3. Given a bonded repair situation, analyze the situation and identify facts and principles pertaining to the curing process IAW technical data.

   a. Use of heat

      1. Types of heating devices

      2. Uses

   b. Use of pressure

      1. Types of pressure

      2. Uses

   c. Considerations for curing of parts

4. Given a metal bonded repair situation, analyze the situation and identify the facts and principles concerning trimming and final finish IAW technical data.

   a. Trim of panel to specifications

   b. Check panel for dimensions

   c. Application of sealant

use trans CT75-C168 thru CT75-C173 and CT75-C183 thru CT75-C184

CONCLUSION TIME: 5 Min.

SUMMARY AND REMOTIVATION:

Now that we have had our discussion about repairs, procedures, techniques, and methods, we should be able to understand the importance of good sound repairs made on bonded honeycomb panels and A/C assemblies.

ASSIGNMENT AND CLOSURE:
The next lesson will be on inspection and evaluation procedures. It is designed to give you a little insight as to just what the inspectors look for and how they find things out about a panel.

OUTSIDE ASSIGNMENT: Read the following Chapter 6 Inspection and Quality Control Adhesives in Modern Manufacturing.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE	INSTRUCTOR
TNSTI	
COURSE NUMBER: 3AZR53153-3	COURSE TITLE: Introduction to Metal Bonded Repair
BLOCK NUMBER: 1	BLOCK TITLE: Introduction to Metal Bonded Repair

LESSON TITLE: Inspection and Evaluation

LESSON DURATION		
CLASSROOM / LABORATORY	Complementary	TOTAL
D&D 1 hr/Perf. NOne	None	1

POI REFERENCE		
PAGE NUMBER	PAGE DATE	PARAGRAPH
4	2 July 1975	5a

STS/CTS REFERENCE	
NUMBER	DATE
CH52-3AZR53153-3	14 April 1975

SUPERVISOR APPROVAL			
SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION			
EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	3AZR53153-3-SG-105, MIL-HDBK-23A MIL-A-83376 MIL-A-83377 Transparencies: Metal Bonded Repair Process

CRITERION OBJECTIVES AND TEACHING STEPS

5. Inspection and Evaluation

a. Without reference, identify the general principles and basic facts concerning inspection of metal bonded structural repairs IAW technical data.

Teaching steps are listed in Part II

ATC FORM AUG 72 770

SAFB IL 36-2608

INTRODUCTION TIME: 5 Min.

Attention: Have you ever wondered why some guy in a white hat can just come up to you and say you made a boo boo. Have you ever been in the situation where you thought what you did was right only to have an inspector tell you you were wrong. This my friends is called Q.C.

Review: In your last lesson and previous lessons you learned what this thing called bonding is all about. Now comes the kicker the testing of your part to see if it will meet the standards.

Overview: This next lesson is on inspection and evaluation approx 1 hr.

Motivation: The strange reasoning behind Q.C. is sometimes puzzling but once you know how they operate it is easier to live with.

BODY TIME: 50 Min

Presentation

1. Inspection and Evalutation

a. Without reference, identify the general principles and basic facts conerning inspection of metal bonded structural repairs IAW Tech Data.

(1) Process Control

a. container condition

b. pre fit

c. surface preparation

d. adhesive application

e. assembly

f. curing

Presentation

Discussion

Reference: MIL-HDBK-23A
MIL-A-83376
MIL-8-83377
3AZ 853153 3-56-105

Trans CT75-C187 thru CT75-C208

(2) Bond Inspection and Testing

a. Non destructive testing

1. appearance

2. tap test

3. ultrasonic tests

4. radiography

b. Destructive Testing of the Bond

1. Tensile tests

2. Shear and lap shear tests

3. Peel tests

CONCLUSION | TIME: 5 Min.

Summary and Remotivation:

Now we should be able to handle it when the inspector puts his mark on your job for better or for worse.

Assignment and Closure: No Assignment. The test, critique and graduation will follow.

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PREPARE THE MAN

STUDY GUIDE

3AZR53153-3-SC-100

Technical Training

INTRODUCTION TO METAL BONDED REPAIR

13-4

30 December 1975

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

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Supersedes ST 3AZR53153-6-SG-100, 3 April 1975.
OPR: TWS
DISTRIBUTION: X
TWS - 100; TTVGC - 1

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Metals Technology Branch
Chanute AFB, Illinois

3AZR53153-3-SG-101

COURSE ORIENTATION AND SAFETY

OBJECTIVES

1. Given job performance situations, analyze the situations and identify safety precautions to be observed during job performance.

2. Given repair material handling situations, analyze the situations and identify the safety precautions to be observed.

INTRODUCTION

The introduction to metal bonded repair course, is a supplemental training course designed to familiarize you with the principles and techniques used in the repair and rebuilding of metal bonded aircraft structures. This study guide together with the classroom instruction will brief you on the organization and policies related to this course. It will also provide information on the safety practices which you must follow if accidents and injuries are to be avoided.

INFORMATION

ORGANIZATION AND POLICIES

This course is conducted by the airframe branch which is part of the 3340th Technical Training Group at Chanute Technical Training Center. As a student attending the course, you must observe certain established school policies. You will be briefed on these policies which include conduct, school duty hours, break periods, clean-up, remedial instruction, classroom locations and other facilities.

Organizational Structure

You will be given the names of the following personnel:

1. Branch Chief.

2. Instructor Supervisor.

3. Instructor or instructors of the course.

Course Content

This course consists of one block, having 40 academic hours.

Location of Tools and Equipment

You will be given a tour of the facilities and shown the tools and equipment used in the repair of metal bonded structures.

Examination and Grading

The examination consists of written multiple choice questions. Your grade will be determined from the score you make on the examination.

Student Critique

At the end of the course, you will be given an opportunity to record your opinion of this course, the base facilities, and the student group.

SAFETY

"An ounce of prevention is worth a pound of cure." This old proverb, when applied to safety, means that if accidents are prevented many lives and wasted man-hours can be saved. Accidents don't just happen, they are generally caused. Only the individual can make a safety plan work. This can be done by observing and following good safety practices.

Handtool Safety

Misuse of handtools is the biggest cause of handtool accidents. Remember, although handtools may be simple devices, training is necessary for correct usage. Your tools must be kept clean and in good repair. Cutting tools should be kept sharp; handles should be free from flaws. Use the tool for the job it was designed to do.

Power Tool Safety

Air powered handtools, because they are mobile and difficult to guard, present many hazards to the operator and others in the vicinity. Since the tools are handled manually, dropping is always a hazard. Accidental operation of the air valve is the cause of numerous accidents. Flying chips and parts of broken tools are dangerous when allowed to strike the body.

Hose laid across aisles and traveled areas creates a tripping hazard. When an air hose is struck by a person or object, it may unbalance the tool's operator, causing him to fall or to drop the tool. If a hose coupling breaks, the air hose may whip about, possibly causing injury. It is also a misuse of the air equipment to clean out tools or to remove dust from clothing with compressed air.

Air power tools are sometimes clamped in vises and used as stationary tools. When this is done with little thought given to jig design, injuries can result from the tools slipping and falling.

Air power tools used in buildings or on pavement may contact electrical power lines, causing shock to the operator. Sparks and hot chips from air power tools may cause a fire or an explosion when used in a flammable atmosphere.

Material and Chemical Safety

Fiberglass is made of glass threads. During sawing or sanding operations avoid breathing fiberglass dust, and keep the glass thread from coming in contact with your skin. It may cause irritation and be harmful to the eyes. Take all necessary precautions to prevent contact with the fine glass threads and dust.

Chemicals are used in highly concentrated solutions in many industrial processes and laboratories, and workers who handle them may be exposed to the hazard of chemical burns. The severity of such burns can often be limited to a considerable extent by prompt application of proper first-aid measures.

Pending medical treatment, initial first-aid for every chemical burn is to wash off the chemical by flooding the burned area with copious amounts of water as quickly as possible. This is the only method of limiting severity of the burn, and the loss of even a few seconds can be vital. Soap through its mechanical action will also help to remove chemicals from the skin. Following complete washing, the burn should be covered with a clean, dry, sterile cloth or sheet. Contaminated clothing should be removed and disposed of.

Handling of chemicals should be done with extreme caution. Personal protective equipment must be used. Use the table of "chemical hazards" given in AFR 127-101; it gives you an outline definition of various categories of chemicals and the characteristics of each.

Some of the cleaners and resin mixtures used in fiberglass repairs are very toxic and can cause nasal or skin irritation. Be sure the working area is well ventilated. Avoid prolonged breathing of these materials. To prevent skin irritation, wash with soap and water at frequent intervals.

The mixing of some resins is dangerous and could cause a violent explosion if done improperly. Always mix the promoter with the resin and then add the catalyst, or first add epon mixer and then a curing agent.

Ventilation

Have you ever thought about why you need ventilation in your shop area? Ventilation is required to protect the health of employees who work where dust, fumes or mist created by a manufacturing process is released into the atmosphere.

Except for the skin diseases, most occupational diseases are acquired by inhalation of material. Certain dusts that reach the lungs can pass directly into the blood stream and be absorbed over a long period of time. Others may stay in the lungs and set up local irritation or damaging action. Toxic and irritant dusts can also be ingested in amounts that may cause trouble. Toxic materials that are readily soluble in body fluids can be absorbed in the digestive system and picked up by the blood. A third way in which toxic and irritant substances may enter the system is skin absorption. Many organic compounds such as TNT, cyanide, and most aromatic amines, and phenols can produce systemic poisoning by direct contact with the skin. Contact of toxic and irritant dusts with the skin may also result in skin irritation.

There are two types of ventilation, general and mechanical. The general or natural ventilation is the flow of air in an area. This flow of air could also be helped along by fans. The mechanical ventilation generally refers to a forced exhaust system set up in a localized area to remove dust or fumes from a specific area. It should also be noted that when a lab or shop uses mechanical ventilation in one area, general ventilation usually improves throughout the shop.

Jewelry

There are many ways of losing a finger because of a ring being worn. When releasing the hold on a piece of equipment being carried, a ring can easily hang on some projection and put all the weight on one finger. In the next instant, the finger could be torn from the hand. There have been cases where a finger was lost because of a ring being worn. In one case a mechanic wearing a ring dropped from an aircraft bomb bay; the ring caught on a ledge, causing the finger to be severed. It is easy for a neck chain to catch on a piece of moving machinery and either choke the individual or cause his face to be drawn into the machinery. Watchbands can hang on an object and cause the hand to be forced into a position where it could be mutilated. Play it safe. At the start of the working day, remove all jewelry and put it away until the day's work is finished.

Eye Safety

Nearly all eye injuries can be prevented by the use of properly designed goggles. Goggles are classified into different types according to the hazards which they guard against. Impact goggles or a face-shield should always be worn by all personnel when work may produce flying chips or debris. Some of the operations or duties requiring the wearing of goggles are: grinding, sanding, routing, using cutting tools, and working with acids, alkalines, and paint remover. There are many others.

Ear Safety

The Air Force is very concerned about the hazard of noise caused by the operation of certain tools and equipment.

One effect of noise is fatigue. Human beings have a strong desire to get away from noise. Add excessive noise to the stress created by hard work, dangerous situations, and conditions of cold, heat or other discomforts, and the total stress becomes tremendous. As a result the body is fatigued, less alert, and less respondent. This condition causes mistakes, even accidents.

A second effect of excessive noise is temporary or permanent loss of hearing. Just as temporary blindness may be caused by a very bright light, so temporary deafness may be caused by excessive noise. In fact, the deafness may become permanent if there is a severe exposure to noise such as an explosion, or if a temporary loss of hearing is produced over and over again.

A third factor is pain. Pain, in general, is a warning signal of injury to body tissue. A noise may not be strong enough to produce pain but may be strong enough to produce permanent deafness if repeated often enough. Remember, ear plugs may not be enough protection when worn alone. To be fully protected you must also wear ear muffs in conjunction with ear plugs.

Accident Reporting

If an accident does happen, even a scratch, report it. Why, for just a scratch? The Air Force desires to protect all personnel from the chance that an accident may not be trivial. To illustrate from an actual case in the March AFB files: A carpenter was using a circle saw when the blade "exploded." He received a small cut on the head and someone placed a band aid over the small opening. He was helping in the search for a missing piece of the blade when he collapsed. Though he regained consciousness after reaching the hospital, he later died. An X-ray revealed that a piece of the blade had embedded deep in his brain. Do not ignore even the smallest cut.

IMPORTANT SAFETY PRACTICES

The following is a list of some of the important safety practices which should be adhered to when in and around a bonding shop.

1. The nearest instructor must be informed immediately of every accident or injury.

2. Think! Look and pay attention to everything you do.

3. DANGER, WARNING, CAUTION, NO SMOKING, FLAMMABLE, and NOTICE are signs which should be read and heeded.

4. Horseplay will not be tolerated here during your class periods and not at your home base.

5. Keep the area neat. Provide a place for everything and keep everything in place.

6. Goggles and protective type clothing (gloves, aprons, respirators) are provided for a specific purpose - wear them!

7. Under no circumstances will compressed air be used to clean dirt or debris from work areas, nor will it be directed at a fellow worker.

8. Strains, pulled muscles, and ruptures occur when heavy objects are lifted improperly. Injuries of this type are entirely unnecessary. There are enough men and lifting equipment in the Air Force to help you hoist the world on your shoulders.

9. Never operate or use tools, machinery, or equipment unless a demonstration has been given and the safe operating procedure is known.

10. Make sure all existing guards are in place on tools, machinery or equipment. Design new guards if old ones are unsatisfactory.

11. Use the right tool for the job. Use the tool correctly.

12. Use tools that are in good condition, not cracked or badly worn.

13. Practice care when drilling, handling sharp edges of metal, or when using shears.

14. Avoid the possibility of clothing and jewelry becoming entangled in machines and equipment.

15. Report any unsafe conditions of tools, equipment and other hazards.

16. Wear protective equipment when handling chemicals and resins.

Caution: "The life you save may be your own." Think twice; practice safety. Be careful not to lose an eye or finger or break a bone. Although many of these practices can not be applied here in class because we won't really get into some of these situations, they should be applied in the actual shop area. We will also discuss some of the safety procedures outlined in some of the National Safety Council data sheets later in the course.

SUMMARY

Safety cannot be overstressed due to the many hazards involved wherever there are machines or personnel. You are required to know and observe all safety practices pertaining to the job. It is not only your duty to observe these practices, but also to help others observe them. The best way to accomplish a job is the safe way. Think "SAFETY."

QUESTIONS

Note: Answer the following questions on a separate piece of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. What must be done immediately if ar accident or injury occurs?

2. List a few good reasons why horseplay is not permitted.

3. What are some of the first steps taken when sustaining a chemical burn?

4. What does safety mean to you?

5. What are some safety practices to follow when using tools, machinery and equipment?

REFERENCES

1. AFR 127-101, Ground Accident Prevention Handbook.

2. National Safety Council Data Sheet 392, Air Powered Handtools.

3. National Safety Council Data Sheet 523, Chemical Burns.

4. National Safety Council Data Sheet 531, Dusts, Fumes, and Mists in Industry.

MODIFICATIONS

Pages 11 - 12 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

Metals Technology Branch
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3AZR53153-3-SG-103

INTRODUCTION TO METAL BONDED STRUCTURES

OBJECTIVES

1. Without reference, identify the principles involved in bonding adhesive joints.

2. Without reference, identify basic facts and general principles as to how a bonded sandwich assembly is constructed and what materials are used in the construction of bonded sandwich assemblies.

3. Given various adhesives, analyze and identify characteristics of the repair materials used in the repair of metal bonded structures.

4. Without reference, identify the basic facts and terms regarding adhesion and polymerization of adhesives.

INTRODUCTION

An adhesive is defined as a substance capable of holding materials together by surface attachment. Currently there are about 25 basic types of synthetic adhesives useful to the design engineer. New types are appearing at an average rate of one per year. Each of these may have from 10 to 20 modifications. When we consider that frequently two or more individual adhesives are combined to provide special properties, this leads to a vast array of specific products from which to choose.

The advent of lightweight construction in aircraft design about 25 years ago, with its corresponding use of thin-gage metal and honeycomb construction, necessitated the development of new concepts in methods of joining and fastening. In England the challenge was accepted and resulted in the development of the first structural adhesive, REDUX, used for joining load-bearing components in aircraft. Shortly thereafter the first commercial aircraft adhesive was produced in the United States. This adhesive was derived from a combination of phenolic resin and neoprene rubber. This type of adhesive is still in use today in modern jet aircraft such as the KC-135.

In this chapter you will read about some of the most important adhesives and the construction techniques used in metal bonded structures.

INFORMATION

HISTORY OF ADHESIVES

The use of adhesives is one of the oldest methods for joining materials. However, adhesive technology progressed very slowly until the twentieth century. Records show that adhesives were used over three thousand years ago. Adhesives derived from bitumin and tar pits were used in early structures. They are known to have been used as mortar by the builders of the Tower of Babel. The Egyptians used glue formulated from tree resins and eggs. A Biblical example of the knowledge of adhesives is recorded in the twenty-second chapter of Ecclesiastes. It is indicated here that proper selection of an adhesive must be made to be compatible with the substrate being joined. Engineers are still struggling with problems similar to the one recorded in the Biblical verse "he that teacheth a fool is like one that glueth potsherd together." (Potsherd was a fragment or broken piece of earthenware.)

There was very little advancement in adhesive technology until the twentieth century. Great strides were made in metal bonding due to the military requirements of World War II. The early metal bonding adhesives combined phenolic resins with neoprene and nitrile rubber, which produced a tough metal with good peel and shear strengths.

In 1950, experimentation begin in earnest with the epoxy formulations, which offered equal strength properties. In general, they were preferred due to their low solvent content and 100 percent reactive ingredients.

The adhesive industry has grown at a rapid rate since the early fifties but the major increase has occurred in the last few years.

The field of structural adhesives will continue to grow. New formulations are in constant demand. There is no universal adhesive. Design engineers are searching for the lightest possible design for structures consistent with structural integrity. The many types and classes of adhesives have varying properties. New uses for adhesives are being discovered. Since there is no universal adhesive, the competition runs high and the rewards are rich for those engaged in advancing technology.

DESIGN CONSIDERATIONS

When joining materials with adhesives, initial design considerations must include not only the physical and chemical characteristics of the adherends and adhesive but also the operational environment that the bonded parts will encounter. Maximum bond integrity can only be realized when everything in the joining operation is carefully examined, particularly those factors related to the surfaces of the materials being bonded. The major chemical and physical phenomena that must be considered in establishing a strong joint are:

1. Surface condition of the adherends.

2. Surface tension of adhesive and "weldability" of the material being bonded.

3. Physical properties of the adherends and the cured adhesive, i.e., tensile strength, shear strength, compressive strength, etc.

4. Physical characteristics of the adhesive, i.e., viscosity, homogeneity, film thickness.

5. Chemical compatibility of the adhesive and adherend.

6. Methods of applying and curing the adhesive.

7. Formation and removal of volatile by products during cure.

The surface condition of adherends themselves is most important in the formation of a strong adhesive bond. From a practical viewpoint all solid surfaces are rough and, when viewed under a microscope, appear to consist of hills and valleys and sometimes craters. These surfaces have moisture, gases, and other substances on them which are absorbed from their surrounding environments. By displacing these absorbed substances from the surface of the adherends, a properly formulated adhesive can usually form a strong tenacious bond. Because of the wide variations in porosity, surface conditions, and chemical characteristics of these surfaces, care must be exercised in the selection and application of the adhesive. Particular attention must be given to surface preparation, for failure of bonded joints usually occurs at the interface between adhesive and adherend.

In the classical adhesive bonded joint there are five separate components that must be considered: first adherend, first interface, adhesive film, second interface and second adherend.

If a suitable selection of adherends and adhesive has been made, if the surfaces of the adherends have been cleaned and prepared correctly, and if the adhesive has been applied by the recommended procedures, a high strength joint should result. Maximum performance can only be achieved, however, by properly engineering construction of the joint to withstand the various environments and stress to which it will be subjected.

With these concepts in mind, it is readily apparent that the design and bonding of high performance adhesive joints is not a simple matter.

HONEYCOMB SANDWICH CONSTRUCTION

In the aircraft industry honeycomb sandwich construction, illustrated in figure 1, is used extensively in the manufacture of control surfaces, bulkheads, flooring, doors, engine cowlings, helicopter blades, and wing panels. The primary reasons for using sandwich designs in preference to other types of construction are:

1. High strength - to weight ratio.
2. Fatigue resistance.
3. High rigidity per unit weight.
4. Surface smoothness.
5. Insulation.

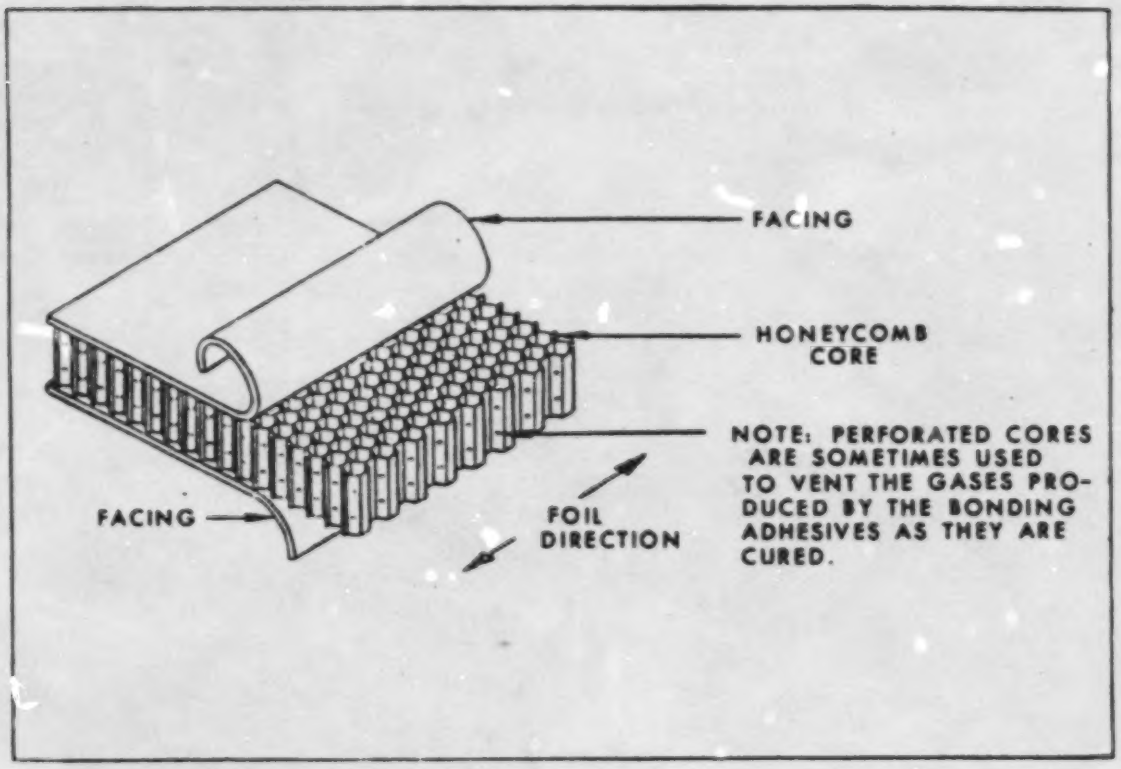
FACING
HONEYCOMB CORE
NOTE: PERFORATED CORES ARE SOMETIMES USED TO VENT THE GASES PRODUCED BY THE BONDING ADHESIVES AS THEY ARE CURED.
FACING
FOIL DIRECTION

Figure 1. Honeycomb Sandwich Construction.

Sandwich structures are produced by adhesively bonding rigid facings on both sides of a honeycomb core. Functionally, the sandwich structure can be compared to an I-beam where the facings resist tensile and compressive loads as do I-beam flanges; the honeycomb core simulates the web of the I-beam by carrying the shear stresses. In addition, however, the core provides continuous support for the facings, allowing their full strength to be utilized without buckling or crimping. It is the function of the adhesive in sandwich structures to transmit shear loads uniformly from the facings to the honeycomb core; good adhesive filleting is necessary in honeycomb bonding. For the completed panel to have optimum strength the adhesive must be distributed evenly between the core and the facings to form a T-joint.

The most popular core-to-skin adhesives are based on epoxy resins because of their high strength and good wetting properties with only minimal volatiles produced during the bonding operation. Vinyl-phenolic and elastomer phenolic adhesives also widely used but are less likely to form dense fillets. Primers are frequently used with these latter systems.

Honeycomb cores can be made from many materials including steel, titanium and aluminum foils, glass reinforced plastics, films, and papers. The variety of available facing materials gives the engineer a considerable amount of flexibility in the design of sandwich structures. Selection of the proper core-to-skin adhesive is dependent upon the materials involved, the application, environmental exposures, service life, and weight considerations. Adhesives can be applied to core and facings with a spray gun or roller, but in structural applications adhesive films of controlled thickness are generally used. For many of these applications lightweight adhesives in the range of .025 to .080 pound/square foot are used with curing cycles of 15 to 60 minutes at 225° to 250°F. Bonding pressures are usually in the 25 to 50 psi range, but depending upon the specific application these pressures can vary from contact to 150 psi. While the emphasis has been on the lower curing temperatures, many modified epoxy and phenolic adhesives are formulated to cure around 350°F. Postcuring temperatures of 500° to 550°F are required in the case of polyimide adhesives.

Edge Treatments (Close-Out)

Although sandwich structures are highly efficient, the manner in which loads are transmitted into and out of the sandwich largely governs service performance. Good design practice closes off the edges in sandwich panel construction to provide edge reinforcement for the transfer and distribution of edge attachment loads. Sandwich close-out and fastener design objectives are ease of fabrication, proper transmittal of shear loads and resistance to edge peel. As with any adhesive joint, stress concentrations are to be avoided and sandwich fasteners are so designed as to distribute loads evenly over a broad area. Prefabricated inserts and edging of wood, metal and reinforced plastic, epoxy potting compounds, and other materials can be used to provide the necessary strength and load distribution. Figure 2 illustrates various close-out techniques for honeycomb panels. Modifications of the details are commonly made to meet specific load and connection objectives. In each case, the criteria of cost, weight, strength, and ease of fabrication must be carefully considerated. Corner details are easily developed as intersections of these basic closeouts.

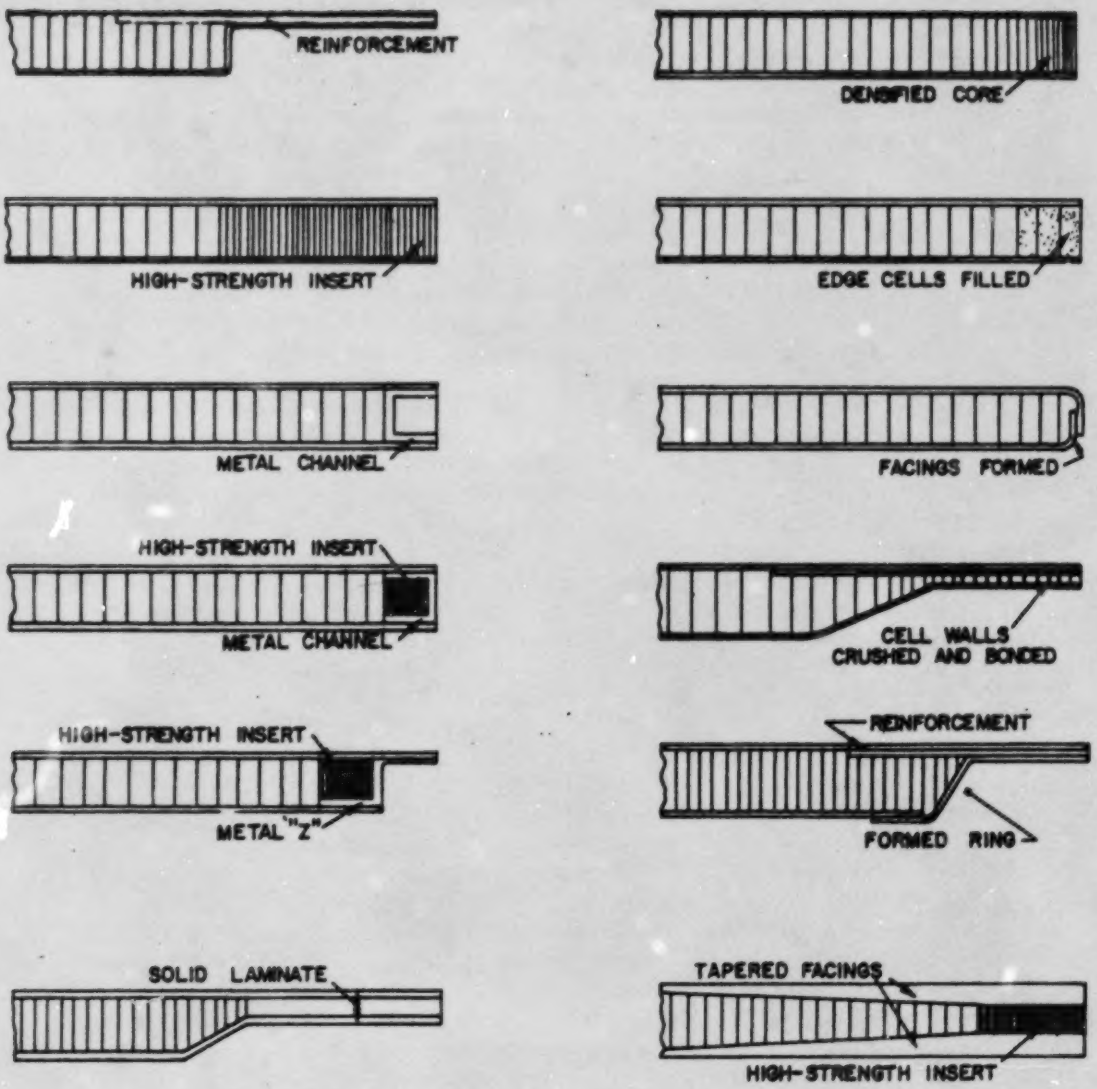

Figure 2. Edge Treatments.

Glossary of Terms

ACCELERATE. To speed up a reaction of process. Example: drying an adhesive or sealer faster than normal by increasing the temperature.

ACCELERATOR. A material added to an adhesive (generally a liquid compound) to convert the whole mass into a solid, or speed up its cure. (Accelerators differ from catalysts in that they lose their identity in the process.)

ACTIVATE. To change an adhesive film from a dry or dormant stage into a useful, sticky state.

ADHERE. To bond; to cause two surfaces to be held together by adhesion.

ADHERENDS. Materials that are held together by an adhesion.

ADHESIVE. By one broad and elementary definition, an adhesive is any substance used in promoting and maintaining a bond between two materials. To function, an adhesive must bond to both mating surfaces through specific adhesion (molecular attraction), through mechanical anchoring (of tendrils in voids of porous surfaces) or through fusion (partial dissolution of both faying surfaces in the adhesive or its solvent vehicle). Various descriptive adjectives are used with the terms "adhesive" to indicate different types, such as:

1. Physical form - liquid adhesive, film adhesive, etc.

2. Composition - resin adhesive, rubber adhesive, etc.

3. End use - metal-to-metal adhesive, plastic adhesive, rubber adhesives, etc.

4. Application - sprayable adhesive, hot metal adhesive, etc.

ADHESION. The state in which two surfaces are held together by interfacial forces which may consist of interlocking action (mechanical means), or valence forces, or both. Adhesion failure occurs when no bond is formed between an adhesive and adherend or when a very poor bond is formed.

AGING. The deterioration or other effect produced by exposure of an adhesive, coating or sealer to a given set of conditions for a specific length of time.

AIR DRYING ADHESIVES. Adhesives that can be dried at ordinary room temperature without the use of heat. This type of adhesive consists of solid particles dissolved or dispersed in a liquid. When the liquid evaporates it leaves the dry adhesive film. Mast elastomer-based adhesives are of this type.

AMS. Aeronautical material specifications written by the Society of Automotive Engineers for use by aircraft and allied industries in specifying adhesives, coatings and sealers especially adapted to aviation use.

ANGLEPLY LAMINATE. Containing plies alternately oriented at plus and minus a fixed angle to the reference direction.

ANISOTROPIC. Not isotropic; exhibiting different properties when tested along axes in different directions.

APPLICATION. The act of applying adhesives. For adhesives and coatings the principal methods of application are: brushing, spraying, dipping, stenciling, flowing, stamp-padding, roll coating, knife-coating, squeegeeing, spatula and notched trowel. For sealers: spatula, caulking gun, flow gun, pressure extrusion units and spray gun.

ASSEMBLY. A group of materials or detail parts, including adhesives, placed together for bonding or which has been bound together.

AUTOCLAVE. A round or cylindrical oven where heat, vacuum and pressure are controlled in the bonding and curing of adhesive in an assembly.

AXIAL LOAD. A weight placed to exert pressure or load in the direction of, along, or on a straight line through the center of an object.

BAG BONDING. A method whereby a flexible cover is used in connection with a rigid die or mod in which pressure or the drawing of a vacuum is applied to the assembly being bonded.

BALANCED LAMINATE. A composite laminate whose layup is symmetrical with relation to the mid plane of the laminate.

BINDER. The component in an adhesive which is primarily responsible for its cohesive properties.

BLEEDER CLOTH. A nonstructural layer of material used in manufacture of composite parts to allow the escape of excess gas and resin during cure.

BLISTER. A local elevation of the surface, possibly caused by trapped air, water or solvent layer area (void) in which there is a lack of bond.

BLOCKING. An undesired adhesion between two surfaces usually occurring when coated or primed parts are stacked for storage.

BOND. To join materials by means of an adhesive.

BOND LINE. All areas in an assembly containing adhesive bonding material, also known as glue line.

BOND STRENGTH TEST. The force per unit area or strength necessary to rupture a bond.

BONDING FIXTURE. A tool or mold used to hold the detail parts of an assembly in place during bonding.

B - STAGE. An intermediate stage in the polymerization reaction of certain thermosetting resins; the state in which most prepregs are stored and shipped.

CATALYST. A substance which speeds up the cure of an adhesive compound without its identity being changed in the process-also known as a hardener.

CAUL. A cover or overlay used to exert uniform pressure at the bond line when pressure is applied to the bonding fixture.

CAUL PLATE. A smooth metal plate used in contact with the layup during cure to transmit normal pressure and to provide a smooth surface to the finished laminate.

COLLIMATED. Rendered parallel, applies to filaments.

COMPOSITE. Composites are combinations of materials differing in composition or form on a macroscale. The constituents retain their identities in the composite. Normally the components can be physically identified and there is an interface between them.

CONTACT MOLDING. A process for molding reinforced plastics in which reinforcement and resin are placed on a mold, cure is either at room temperature or by oven heat, no pressure is applied.

CORE. The central member of sandwich construction (can be honeycomb material foamed plastic or solid sheet) to which the faces of the sandwich are attached.

CORROSION. A deterioration of metal by chemical or electrochemical attack. Surface corrosion appears as a general roughening, etching or pitting, frequently accompanied by a powdery deposit of corrosive products.

COUPLING AGENT. That part of a sizing or finish which is designed to provide a bonding link between the reinforcement and the laminating resin.

CRAZING. A network of minute cracks or fine wrinkles appearing on or under a surface.

CREEP. The dimensional change of an adhesive under load - also known as squeeze-out or flash. Creep at room temperature is sometimes called cold flow.

CROSSPLY LAMINATE. Containing lamina alternately oriented at 0° and 90°.

CURE. To irreversibly change the properties of a thermosetting resin by chemical reaction, i.e., condensation, ring closure, or addition. Cure may be accomplished by addition of curing (crosslinking) agents, with or without heat. A change in the physical

properties of an adhesive by chemical reaction usually accomplished by the action of heat and catalysts, alone or in combination, with or without pressure.

CURING AGENT. That part of a two part adhesive which is combined with the resin (binder) to produce a cured adhesive.

CURE CYCLE. The total period elapsing between the time the adhesive bond is raised to a predetermined temperature, stabilized and is cooled to a specific temperature.

CYCLE. The complete sequence of operations in a process or part of a process.

COHESION. The internal strength of an adhesive film rather than its adhesion to the adherends.

CONSISTENCY. Comparative fluidity or stiffness of an adhesive coating.

DELAMINATE. To split a laminated material along the plane of its layers. Sometimes, used to describe cohesive failure of an adherend in bond strength testing. The separation of the layers of material in a laminate.

DETERIORATION. Undesired change in properties of an adhesive, caused by aging, weathering or exposure of other agents and conditions.

DESTRUCTIVE TEST. Actual destruction of a bonded assembly for the purpose of evaluating the bond properties.

DETAIL. A single piece of material without any attachments.

DIE. A tool or device for imparting a desired shape to a material.

DOUBLER. A material used for strengthening and reinforcement of localized areas.

DRAPE. The ability of broadgoods to conform to an irregular shape.

DRUM PEEL TEST. A test made on bonded strips of metal by peeling the metal strips back and recording the adhesive strength values.

EDGE MEMBER. The structural member around the perimeter of a sandwich panel used to secure the panel to adjacent structures.

ELASTICITY. The property of an adhesive which enables it to resist and recover its original shape and size when deforming forces are removed. The ability to change size or shape repeatedly without breaking.

END. An individual yarn, thread, monofilament, or roving.

ENDOTHERMIC ADHESIVE. A chemically curing type of adhesive which absorbs heat during cure.

EPOXY ADHESIVES. Adhesives based on resins formed from the reactions of epichlorhydrin with various bi- or polyhydroxyl compounds which offer a combination of high room temperature strength with good load bearing properties. These adhesives have excellent honeycomb filleting properties and exceptional adhesion to metal surfaces.

EPOXY EQUIVALENT. The weight of resin in grams which contains one gram equivalen of epoxy. If it is assumed that the resin chains are linear and that an epoxy group terminates each end, then the epoxy equivalent is one-half the average molecular weight of diepoxy resin, one-third the average molecular weight of triepoxy, etc.

ETCHING. A process of chemically cleaning material surfaces by immersion in an acid or basic solution capable of dissolving the material being cleaned, allowing a desired amount of surface material to be removed - a surface treatment.

EXOTHERMIC ADHESIVE. A chemically curing adhesive that evolves heat during reaction.

EXTENDER. An ingredient, generally having some binding properties, added to an adhesive to reduce the proportion of primary binder needed.

FAYING SURFACE. The inner mating surfaces of a joint, common area of two surfaces that are bonded together with an adhesive.

FILAMENTARY COMPOSITE. A laminate composed of laminae in which continuous filaments are in nonwoven, parallel, uniaxial arrays. Individual uniaxial laminae can be combined into specifically oriented multiaxial laminates.

FILL. Yarn running from selvage to selvage at right angles to the warp in a woven fabric.

FILLER. A relatively inert ingredient of an adhesive compound used to increase its bulk and improve working properties, permanence, strength or other qualities.

FILM, ADHESIVE. A dry film in sheet form with or without reinforcing fabric which is cured by means of heat and pressure.

FINISH. A mixture of materials for treating glass fibers. It contains a coupling agent to improve the bond of resin.

FIXTURE. Tool for holding component parts of an assembly during the manufacturing process - also called a jig.

GEL COAT. A quick-setting resin used in molding processes to provide an improved surface for composites; it is the first resin applied to the mold after the mold-release agent.

HAND LAYUP. The process of placing and working successive plies of the reinforcing material or resin impregnated reinforcement in position on a mold by hand.

HEAT CLEANED. Fiberglass reinforcement which has been exposed to elevated temperatures to remove preliminary sizings and binders which are not compatible with the resin to be applied.

HEAT CURING ADHESIVES. Adhesives that require a definite period to time above room temperature to develop full bond strength. Type can be of one- or two-part composition. The term is usually applied to those adhesives that require 180°F or above to effect a cure.

HEAT REACTIVATE. To soften a dried thermoplastic adhesive film to a sticky stage by application of heat.

HEAT SEAL. To bond or weld a material to itself or to another material by the use of heat. This may be done with or without the use of adhesive, depending on the nature of the materials.

HOLIDAY. A void in an adhesive, whether microscopic or normally visible.

HOMOGENEOUS. Of the same kind, size or nature.

HOT MELT ADHESIVE. A thermoplastic adhesive compound usually solid at room temperature which is heated to a fluid state for application.

HONEYCOMB. Manufactured product consisting of sheet metal, paper, fibrous glass, etc., which has been formed into hexagonal-shaped cells, used as core material for sandwich panels.

INHIBITOR. Any substance that slows or prevents chemical reaction or corrosion.

INTERFACE. The common bondary surface between two substances. Sometimes described as two surfaces with no space between them. The bondary between the individual, physically distinguishable constituents of a composite.

INTERLAMINAR SHEAR. The shear strength at rupture in which the plane of fracture is located between the layers of reinforcement of a laminate.

INTERLOCKING ACTION. Term used to describe the chemical or specific basis for adhesion due to the compatibility of the adhesive with the foundation surface. In theory, the ends of the molecules project above the adhesive and foundation faces. Instead of meeting head-on or repelling each other, they interlock.

INERT. A lack of active properties (adhesive).

ISOTROPIC. Having uniform properties in all directions. The measured properties of an isotropic material are independent of the axis of testing.

JOINT. The location at which two adherends are held together by an adhesive.

"k" FACTOR. Thermal conductivity value usually expressed: K = BTU's/(hours) (square feet) (°F/feet) or, amount of heat transferred (BTUS) in a period of time (hours) over a certain square area (square feet) per degree of difference of temperature per foot of thickness of material (°F/feet).

MASTIC. Any heavy-bodied adhesive of such a consistency that it must be applied by notched trowel, gob or buttering methods.

METHYL ETHYL KETONE. Known also as MEK. A low-boiling ketone solvent, used in many nitrile or synthetic resin compounds.

MONOLAYER. The basic laminate unit from which crossplied or other laminate types are constructed.

NATURAL RESINS. The products obtained from the exudations of trees and sometimes used as adhesive, coatings or sealer bases. Common natural resins are the copals, demar, shellac, accroides, sandarac, rosin and mastic (pale yellow resin from Greece, also known as "tear bum" because of its shape).

NESTED LAMINATE. A laminate in which the plies are placed so that the yarns of one ply lie in the valleys between the yarns in the adjacent ply.

NONBLOCKING. Pertaining to an applied adhesive coating film that will not adhere to itself and/or other surfaces under normal stacked storage conditions. See also BLOCKING.

NONVOLATILE. The portion of an adhesive, coating that does not evaporate at ordinary temperatures. This includes the pigment, drying salts, gum and resin, oils or plasticizers and the binder (rubber, asphalt, vinyl, nitrocellulose, etc.) of the adhesive.

NONWOVEN FABRIC. A fabric, usually resin-impregnated, in which the reinforcements are continuous and unidirectional; layers may be crossplied.

OPEN TIME. Time interval between applying the adhesive and completing the bond.

ORANGE PEEL. A surface irregularity resembling an orange skin in texture.

ORTHOTROPIC. Having three mutually perpendicular planes of elastic symmetry.

PARALLEL LAMINATE. A laminate of woven fabric in which the plies are aligned in the same position as originally aligned in the fabric roll.

PARTING AGENT. A lubricant used to coat a mold cavity to facilitate removal of an assembly from the mold, also known as releasing agent.

PEEL PLY. A layer of resin-free material used to protect a laminate for later secondary bonding.

PHENOLIC RESIN. Resins made by the interaction of phenols and aldehydes; also known as phenol-formaldehyde resins.

PICKLE. A solution or process used to loosen or remove corrosion products such as scale and tarnish from a metal.

PINHOLING. A film defect characterized by the presence of tiny holes on the surface, sometimes extending completely through the film.

PLASTICIZER. For epoxy, a lower molecular weight material added to reduce stiffness and brittleness; it results in a lower glass-transition temperature for the polymer.

PLATENS. Mounting plates of a press used to apply heat and pressure during the bond cure cycle of an assembly.

PLIED YARN. A yarn formed by twisting together two or more single yarns in one operation.

POLYMERIZATION. A chemical reaction in which the molecules of a monomer link together to form large molecules (polymer) whose molecular weights is a multiple of that of the original material without releasing any other substance is referred to as polymerization. When two or more monomers are involved the process is called "copolymerization" or "heteropolymerization."

POSTCURE. Additional elevated temperature cure, usually without pressure, to improve final properties and/or complete the cure. In certain resins, complete cure and ultimate mechanical properties are attained only by exposure of the cured resin to higher temperatures than those of curing.

POT LIFE. The rating in hours of the time interval following the addition of accelerator before a chemically curing adhesive or sealer will become too viscous to pass predetermined viscosity (consistency) requirements. Closely related to WORKING LIFE.

PREPREG; PREIMPREGNATED. A cloth or mat having been impregnated with catalyzed resin and advanced to a "B" state, ready for molding.

PRESSURE SENSITIVE ADHESIVE. Type of adhesive that retains its tack or stickiness even after complete release of the solvent.

PRIMER. Special coating designed to provide new surfaces with adequate adhesion for a coating system.

QUASI-ISOTROPIC LAMINATE. A laminate approximating isotropy by orienting plies in several directions.

REACTIVATE. To restore the tackiness of a completely dried adhesive at the time of use. Reactivated bonds are advantageous in that the adherend may be precoated with adhesive and the bond made when desired with nominal and short term exposure. Reactivated bonds have almost immediate set.

REACTIVATED, HEAT. To restore the surface tackiness of the adhesive with heat, and bond under pressure.

RESIN. Any of a class of solid or semisolid organic products of natural or synthetic origin.

RETARDERS. Combinations of liquids, solvents and extenders that are added to an adhesive coating to slow down the drying rate of the material.

RIBBON FLOW. Longitudinal direction of the foil in the honeycomb.

ROVING. A multiplicity of single ends of continuous filament with no applied twist drawn together as parallel strands.

SCRIM. A low cost reinforcing fabric made from continuous filament yarn in an open mesh construction. Used in the processing of tape or other B-stage material to facilitate handling.

SHEAR TEST. A method of separating two adhesive bonded materials by forcing (either by compression or tension) the interfaces to slide over each other. The force exerted is distributed over the entire bonded area at the same time. Strengths are recorded in pounds per square inch (PSI).

SHELF LIFE. The period of time a packaged adhesive can be stored under specified temperature conditions and remain suitable for use.

SILICONE ADHESIVES. Adhesive compounds of this base have remarkable stability through a wide range of temperatures. Very good dielectric properties.

SIZING. On glass fibers, the compounds which, when applied to filaments at forming, provide a loose bond between the filaments, and provide various desired handling and processing properties.

SOLIDS. Nonvolatile ingredients in an adhesive.

SOLUTION. A homogeneous mixture of two or more compounds in a single phase. The proportion of the components may be varied within certain limits.

SPALLING. The chipping or fragmenting of a surface or surface coating caused, for example, by differential thermal expansion or contraction.

STRAND. A primary bundle of continuous filaments combined in a single compact unit without twist.

STARVED JOINT. A joint that has an insufficient amount of adhesive to produce a satisfactory bond.

SURFACE PREPARATION. The procedure required to clean or prepare a base surface so an adhesive will stick to it firmly. For example, if higher bond strength is required, abrading and/or acid etching metal surfaces can be a means of improving the adhesion of the bonding material to the mating surfaces. Common methods of surface preparation are solvent washing, sand blasting and vapor degreasing.

SYNTHETIC RESIN. Resins prepared by chemical means.

TACK. The sticky quality of an adhesive film, either while wet or after the film has set. Technically it is the pull resistance measured in dynes, exerted by a material adhering completely to two separating surfaces.

TACK BONDED. Low pressure applied to an adhesive film which has a sticky quality enabling it to form a temporary attachment.

TACK RANGE. The time during which an adhesive film remains tacky.

TENSILE STRENGTH. The resistance of a film to distortion or rupture when it is exposed to forces exerted in opposite direction. Measured in PSI.

TIE COAT. One layer of a coating system used to improve the adhesion of adjacent or succeeding coats.

TOW. A loose, untwisted bundle of filaments.

TOXICITY. A term referring to the physiological effect of absorbing a poisonous substance into the system, either through the skin, mucous membranes or respiratory system.

TORQUE TEST. A twisting or turning force applied to inserts to test adhesive bond strength.

TRICHLOROETHYLENE. A solvent.

TWIST. The turns about its axis per unit of length observed in a yarn or other textile strand. Twist may be expressed as turns per inch (TPI). "S" and "Z" refer to direction of twist.

UNDER CURE. Degree of cure less than optimum. May be evidenced by tackiness, softness, off-color or inferior physical properties of an adhesive.

UNIDIRECTIONAL LAMINATE. A laminate with nonwoven reinforcements which are all laid up in the same direction.

ULTRASONIC TEST. High frequency sound waves emitted for void detection in bonded structural panels.

VEHICLE. The liquid portion of an adhesive compound consisting of the binder and volatile thinners.

VISCOCITY. Comparative fluidity or stiffness of liquid adhesives, coatings and sealers.

VAPOR DEGREASING. A cleaning process that employs hot vapors of a solvent to remove oil, grease, waxes, etc.

WARP. The yarn running lengthwise in a woven fabric.

WET LAYUP. A reinforced plastic which has liquid resin applied as the reinforcement is being laid up.

WETTING. The ability of an adhesive to "wet" or adhere to a surface immediately on contact even when the film is reduced to extreme thinness.

WORKING LIFE. Refers to the time interval after mixing the accelerator into the base compound during which the adhesive or sealer can be satisfactorily applied with pressure equipment.

YARN. Generic term for strands of fibers or filaments in a form suitable for weaving.

STUDY ASSIGNMENT

Read chapter 1 of Adhesives in Modern Manufacturing.

QUESTIONS

Note: Answer the following questions on a separate piece of paper. DO NOT WRITE IN THE STUDY GUIDE.

1. How are adhesives of the catalytic plural component class normally provided to the user?

2. An important advantage in the use of epoxies is:

3. Epoxies are particularly useful in joining what type of materials?

4. How will the epoxy bond set or cure faster?

5. What are two potential disadvantages of phenolic adhesives?

6. List two advantages of film adhesives.

7. In some film adhesives what is used to support polymer film and carry part of the load?

8. List four of the seven major chemical and physical phenomena that must be considered in establishing a strong adhesive joint.

REFERENCES

1. Bruno, E. J., editor. Adhesives in Modern Manufacturing. Society of Manufacturing Engineers, Dearborn, Michigan, 1970.

2. TO 1B-52-3, Structural Repair Instructions.

3. MIL-HDBK-23A, Structural Sandwich Composites.

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PRINCIPLES OF REPAIR PROCESSES

OBJECTIVES

1. Without reference, identify basic facts and principles concerning the assessment of damage to metal bonded structures.

2. Given a bonded repair situation, analyze the situation and identify the steps and procedures in the preparation for repair of a bonded panel.

3. Given a bonded repair situation, analyze the situation and identify the steps and procedures associated with the fabrication and prefit of repair parts.

4. Given a bonded repair situation, analyze the situation and identify the types and methods of cleaning metal bonded structures.

5. Given a bonded repair situation, analyze the situation and identify facts and principles related to the lay-up and assembly of the repair materials.

6. Given a bonded repair situation, analyze the situation and identify facts and principles pertaining to the curing process.

7. Given a metal bonded repair situation, analyze the situation and identify the facts and principles concerning trimming and final finish.

INTRODUCTION

When repairing or rebuilding a metal bonded structure, it is necessary to follow a certain procedure if the repair or rebuilding process is to be successful.

In the following study assignment you will review the guidelines that must be followed to ensure a good job and minimize repeated repairs to metal bonded structures.

STUDY ASSIGNMENT

Read the following chapters of Adhesives in Modern Manufacturing: Chapters 2, 3 (pages 59-66), and 4 (pages 89-98).

QUESTIONS

Note: Answer the following questions on a separate piece of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. Name two advantages of joining structures with adhesives.

2. Name two disadvantages of joining structures with adhesives.

3. What are the two general operational parameters that should be kept in mind when bonding materials with adhesives?

4. Identify at least four of the six common types of joints described in the text.

5. From the information in the text what is meant by adhesive?

6. Before choosing a method of applying the adhesive the user should consider a few things; list at least three things to be considered.

7. Name the five basic methods of chemical cleaning used on adherends.

8. By what three methods can degreasing of an adherend be accomplished?

9. List the three basic methods of adhesive application to assemblies.

REFERENCE

Bruno, E. J., editor. Adhesives in Modern Manufacturing. Society of Manufacturing Engineers, Dearborn, Michigan, 1970.

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INSPECTION AND EVALUATION

OBJECTIVES

Without reference, identify the general principles and basic facts concerning inspection of metal bonded structural repairs.

INTRODUCTION

Quality control of a bonded joint involves making sure that a certain level of reliability is achieved in a joint. Quality control also performs the important function of compiling statistics on defects for the availability of all accountable bonding personnel. Reliability is achieved by a thorough in-process control from the time the raw materials come in until the last finishing operation is completed. After completing this chapter you should be familiar with the inspection and evaluation of metal bonded structures.

STUDY ASSIGNMENT

Read chapter 5 of Adhesives in Modern Manufacturing.

QUESTIONS

Note: Answer the following questions on a separate piece of paper. DO NOT WRITE IN THIS STUDY GUIDE.

1. List at least one of the three things to look for when inspecting the condition of raw material containers.

2. Give a brief description of PREFIT.

3. What is the most commonly used check for proper condition prior to drying after surface treatment?

4. What is the time interval limit for an adhesive coating on a prepared surface of clad aluminum/etched?

5. List the five basic types of nondestructive tests that are performed on bonds.

6. List at least four of the destructive testing methods used to test the bond.

7. Pick one of the above methods and give a brief description of how it is conducted.

REFERENCE

Bruno, E. J., editor. Adhesives in Modern Manufacturing. Society of Manufacturing Engineers, Dearborn, Michigan, 1970.